

# Environmental Science

## A Study of Interrelationships

Twelfth Edition

Enger & Smith

### Chapter 1

## Environmental Interrelationships

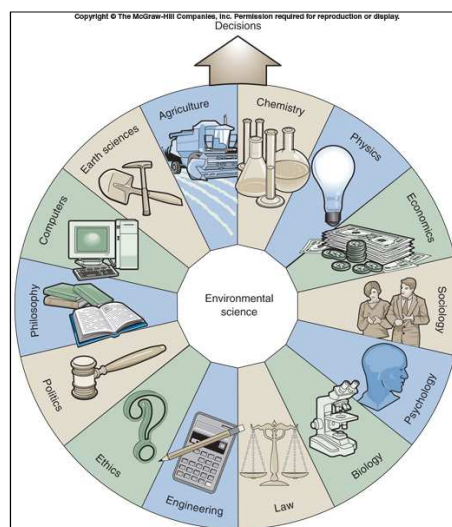
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## The Nature of Environmental Science

**Environmental science** is interdisciplinary, and includes scientific and social aspects of human impact on the world.

- It is a mixture of traditional science, individual and societal values, and political awareness.

**Environment** is everything that affects an organism during its lifetime.



## Interrelatedness Is a Core Concept

- The study of environmental science is so interesting, frustrating, and challenging because of the interrelatedness among seeming unrelated factors.

- *When we try to pick out anything by itself, we find it hitched to everything else in the Universe.*

*John Muir*

*My First Summer in the Sierra, 1911*

## Interrelatedness Is a Core Concept

- The reintroduction of wolves to Yellowstone National Park has resulted in many changes.
- 31 wolves were introduced in 1995.
- In 1996 there were about 320 wolves.
- The wolves have caused water flow changes in the park, increases in willow and aspen trees, as well as songbirds, foxes, certain rodents, hawks, and owls.
- Coyote and elk have declined.

## The “ecology of fear” in Yellowstone

- ❖ “The key is not simply that elk numbers are lower. Populations were similar in the 1960s, when elk were removed or killed by the Park Service, but the saplings were still mowed down. The difference is that the elk won't stand in one place as long with wolves nearby.”

Jeff Welsch article in E Magazine, 2006

## Interrelatedness Is a Core Concept

- ❖ The Yellowstone wolves are connected to social, economic, and political realms of human activity.
- ❖ It was important to environmentalists and biologists to restore the wolf to its former habitat.
- ❖ Ranchers could lose money if wolves killed livestock.
- ❖ The farm lobby fought long and hard in congress to prevent the reintroduction.
- ❖ A fund was developed to pay ranchers for cattle killed by wolves.

## Commoner's 4 Laws of Ecology

(from the *Closing Circle*, 1971)

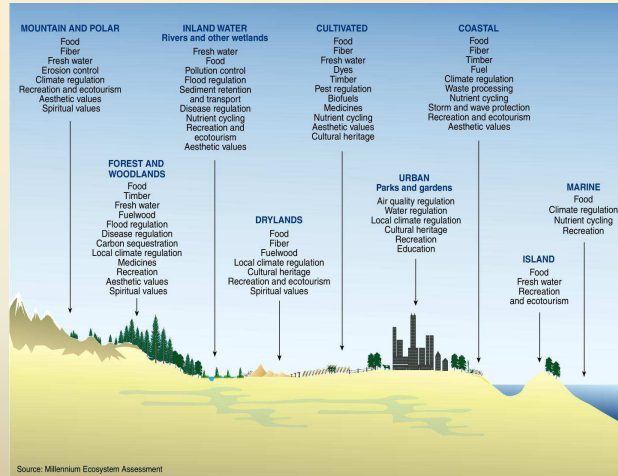
1. **Everything is Connected to Everything Else.**
  - There is one ecosphere for all living organisms and what affects one, affects all.
2. **Everything Must Go Somewhere.**
  - There is no "waste" in nature and there is no "away" to which things can be thrown.
3. **Nature Knows Best.**
  - Humankind has fashioned technology to improve upon nature, but such change in a natural system is, says Commoner, "likely to be detrimental to that system."
4. **There Is No Such Thing as a Free Lunch.**
  - Everything comes from something. There's no such thing as spontaneous existence.

## An Ecosystem Approach

- An **ecosystem** is a region in which the organisms and the physical environment form an interacting unit.
- The task of an environmental scientist is to recognize and understand the natural interactions and changes taking place in the world, and to integrate these with the uses humans make of the natural world.

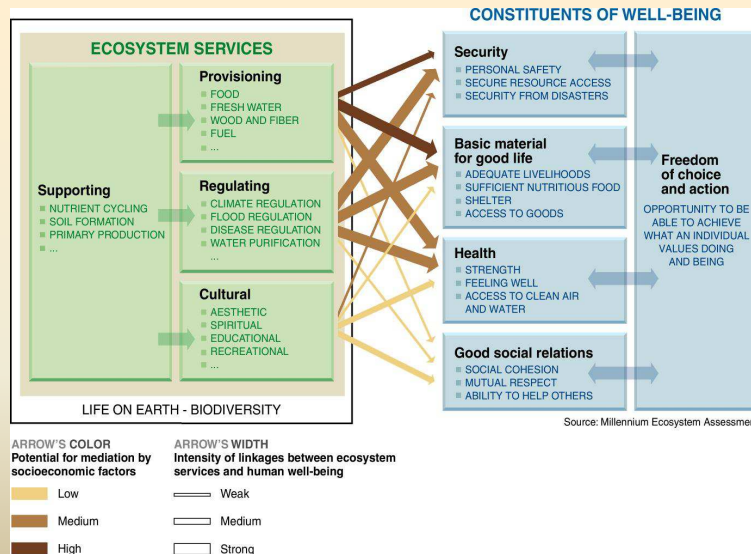
# Millennium Ecosystem Assessment

- Everyone in the world depends on nature and ecosystem services to provide the conditions for a decent, healthy, and secure life



MEA  
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## Consequences of Ecosystem Change for Human Well-being



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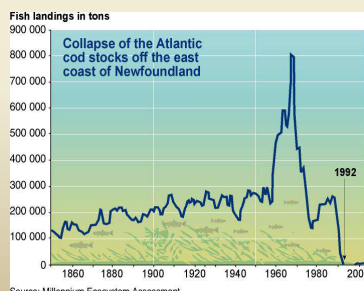
## Unprecedented Change

- Humans have made unprecedented changes to ecosystems in recent decades to meet growing demands for food, fresh water, fiber, and energy
- These changes have helped to improve the lives of billions, but at the same time they weakened nature's ability to deliver other key services such as purification of air and water, protection from disasters, and the provision of medicines
- The pressures on ecosystems will increase globally in coming decades unless human attitudes and actions change

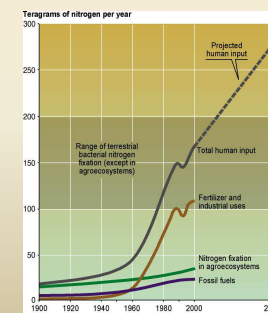
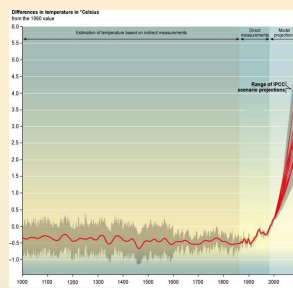
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## Key Problems

- Among the outstanding problems identified by this assessment are the dire state of many of the world's fish stocks; the intense vulnerability of the 2 billion people living in dry regions to the loss of ecosystem services, including water supply; and the growing threat to ecosystems from climate change and nutrient pollution.

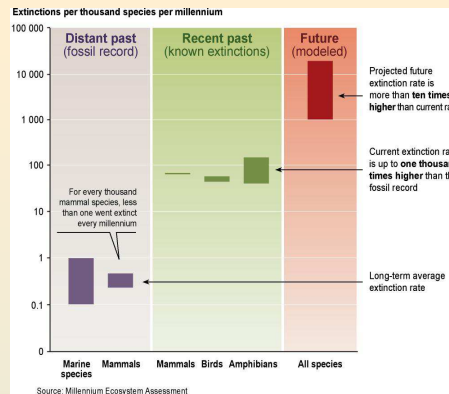


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# Species extinctions

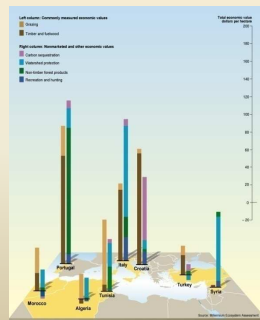
- Human activities have taken the planet to the edge of a massive wave of species extinctions, further threatening our own well-being



MEA Slide

# Consequences for Human Well-being

- The loss of services derived from ecosystems is a significant barrier to the achievement of the Millennium Development Goals to reduce poverty, hunger, and disease



MEA Slide

## MEA: The bottom line

- We are spending Earth's natural capital, putting such strain on the natural functions of Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted.
- At the same time, the assessment shows that the future really is in our hands. We can reverse the degradation of many ecosystem services over the next 50 years, but the changes in policy and practice required are substantial and not currently underway.

MEA  
Slide

## No government bailout for us...

- ✿ Imagine spending more and more money each year, without paying attention to how much you are spending or how much you are making
- ✿ Right now, this is a fair description of how the nations of the world are proceeding
  - World population went from 2.5 billion to over 6 billion from 1950 to 2000
  - Global GNP increased seven-fold during this time
  - By 2000, it was estimated that we were using 20% more resources than the Earth produced each year
- ✿ We can only dip into our savings for so long...

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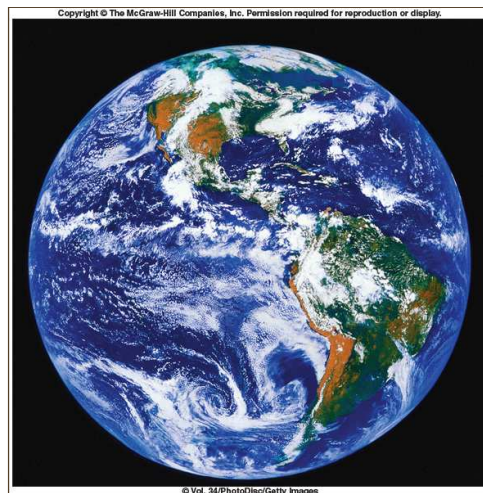
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## Chapter 2

### Environmental Ethics

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## Environmental Ethics



© Vol. 34/PhotoDisc/Getty Images

The Earth as seen from space.

## Environmental Ethics

- **Ethics** is one branch of philosophy; it seeks to define what is right and what is wrong.
- Ethics can help us understand what actions are considered wrong and why they are considered wrong.
- Not all cultures share the same ethical commitments. **Moral relativism** in ethics acknowledges these differences exist.

## Philosophical Approaches to Environmental Ethics

- **Anthropocentrism (human-centered)**
  - This view holds that all environmental responsibility is derived from human interests.
    - Assumes that only humans are morally significant.
    - Assumes nature is an instrument for human manipulation.
- **Ecocentrism**
  - This view maintains that the environment deserves direct moral consideration, not consideration derived from human or animal interests.

## Philosophical Approaches to Environmental Ethics

- “A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise....We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect.”

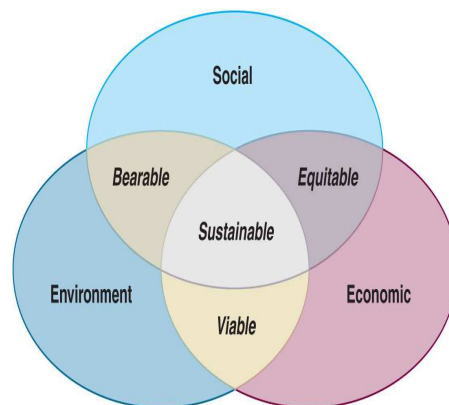
—Aldo Leopold

*A Sand County Almanac, 1949*

## Sustainable Development

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- Sustainable Development is a middle ground that seeks to promote development while still preserving the ecological health of the landscape.



## Environmental Justice

- In 1998, the Environmental Protection Agency (EPA) defined **environmental justice** as fair treatment, meaning:
  - “No group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies.”
  - Environmental justice is closely related to civil rights.

## Environmental Justice

The direct action in Warren County, NC, marked the birth of the environmental justice movement in the U.S.

Studies show that the affluent members of society generate most of the waste, while the impoverished members tend to bear most of the burden of this waste.



(a)



(b)

## Environmental Justice

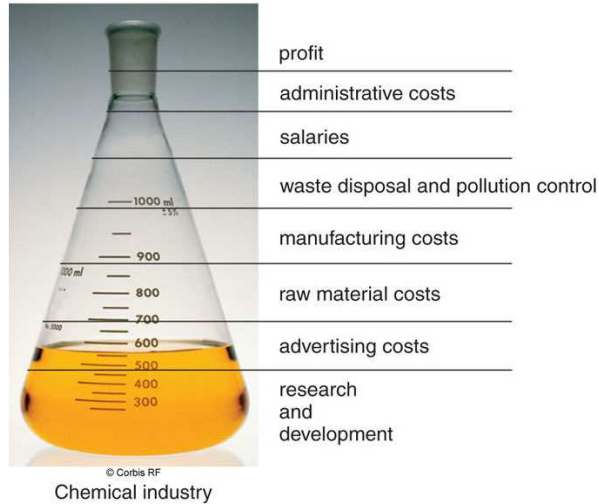
- Environmental justice encompasses a wide range of issues, including:
  - Where to place hazardous and polluting facilities
  - Transportation
  - Safe housing, lead poisoning, and water quality
  - Access to recreation
  - Exposure to noise pollution
  - Access to environmental information
  - Hazardous waste cleanup
  - Exposure to natural disasters (e.g., Hurricane Katrina)

## Societal Environmental Ethics

- Western societies have long acted as if the earth has:
  - Unlimited reserves of natural resources.
  - An unlimited ability to assimilate wastes.
  - A limitless ability to accommodate unchecked growth.
- Until the last quarter of the 20<sup>th</sup> century, economic growth and resource exploitation were the dominant orientations toward the natural environment in industrialized societies.
- Things may be shifting?

## Corporate Environmental Ethics?

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Corporate decision making.

## Corporate Environmental Ethics

- Actions such as dumping waste in a river rather than installing a wastewater treatment facility or using expensive filters **externalize the costs** of doing business so that the public, rather than the corporation, pays those costs.
- Because stockholders expect a return on an investment, corporations can be drawn toward making decisions based on short-term profitability rather than long-term benefit to the environment or society.

## Green Business Concepts

- ✿ It makes little sense to preserve the environment if preservation causes economic collapse.
- ✿ Nor does it make sense to maintain industrial productivity at the cost of breathable air, clean water, wildlife, parks, and wilderness.
- ✿ **Natural capitalism** is the idea that businesses can both expand their profits and take good care of the environment.
  - The 3M Company is estimated to have saved up to \$500 million over the last 20 years through its Pollution Prevention Pays (3P) program.

## Individual Environmental Ethics

- ✿ Ethical changes in society and business can (must?) start with individuals.
- ✿ Individual actions have a bearing on environmental quality and each of us bears some responsibility for the quality of the environment in which we live.

## Individual Environmental Ethics

- Opinion polls conducted over the past decade have indicated Americans think environmental problems can often have a quick technological fix.
  - Many individuals want the environment cleaned up, but do not want to make the necessary lifestyle changes to make that happen.

## The Ethics of Consumption

- North Americans represent 5% of the world's population.
  - North Americans consume one-fourth of the world's oil.
  - They use more water and own more cars than anybody else.
  - They waste more food than most people in sub-Saharan Africa eat.

# Lifestyle and Environmental Impact

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Approximate relative ecological footprint of one person in the developing world.



Approximate relative ecological footprint of one person in the developed world.

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### Chapter 3

## Environmental Risk: Economics, Assessment, and Management

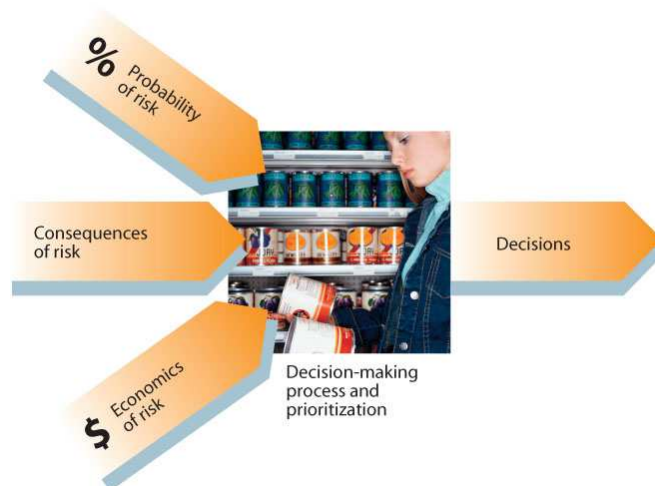
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## Characterizing Risk

- ✿ **Hazard** – inherent potential for something to cause harm (e.g., toxic substances, staircases, car travel)
- ✿ **Exposure** – extent to which something is subject to the influence of a hazard
- ✿ **Risk = hazard x exposure**, or the probability that a hazard will lead to an injury, damage, or loss.
- ✿ Risk incorporates three main considerations:
  1. Probability of a bad outcome.
    - **Probability** is a mathematical statement about how likely it is that something will happen.
  2. Consequences of a bad outcome.
  3. Cost of dealing with a bad outcome.

## Risk and Economics

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Decision-making process

## Risk Assessment

- **Environmental risk assessment** uses facts and assumptions to estimate probability of harm to human health or the environment that may result from particular management decisions.
  - The assessment process provides an orderly, clearly stated, and consistent way to deal with scientific issues when evaluating whether a risk exists, the magnitude of the risk, and the consequences of the negative outcome of accepting the risk.

## Risk Management

- **Risk management** is a decision-making plan that weighs policy alternatives and selects the most appropriate regulatory action by integrating risk assessment results with engineering data, and with social, economic, and political concerns.
  - The purpose is to reduce the probability or magnitude of a negative outcome.

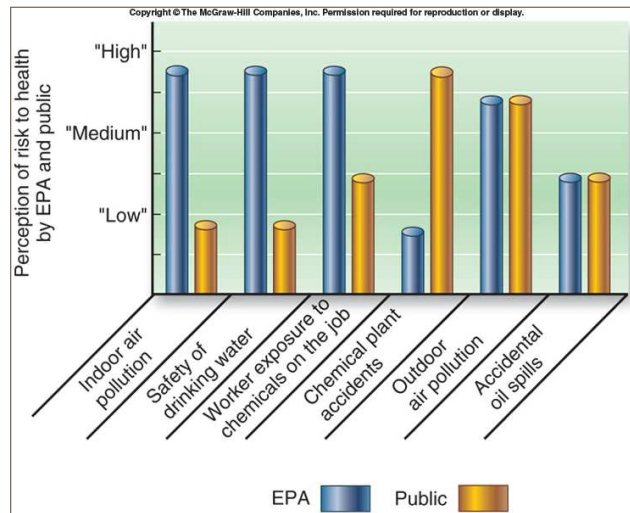
## Risk Management

- A risk management plan includes:
  - Evaluating the scientific information regarding various kinds of risks.
  - Deciding how much risk is acceptable.
  - Deciding which risks should be given highest priority.
  - Deciding where the greatest benefit would be realized by spending limited funds.
  - Deciding how the plan will be enforced and monitored.

## Scientific and Perceived Risks

- People often overestimate frequency and seriousness of sensational causes of death, and underestimate risks from familiar causes that claim lives one by one.
  - [http://www.schneier.com/blog/archives/2006/11/perceived\\_risk\\_2.html](http://www.schneier.com/blog/archives/2006/11/perceived_risk_2.html)
  - People afraid to fly will drive great distances instead, even though this behavior has a much greater risk associated with it

## Scientific and Perceived Risks



Perception of risks

## Scientific and Perceived Risks

- One of the most profound dilemmas facing decision makers is how to address the discrepancy between the scientific and the public perceptions of environmental risks.
  - Should the government focus available resources and technology where they can have with the greatest impact, or on problems about which the public is most upset?
    - This is a science vs. politics question and has great impacts on society

## Should we...

- Use genetically modified organisms in agriculture to help grow more food?
- Expand nuclear power generation to replace fossil fuel use?
- Use DDT to kill mosquitoes in tropical areas to prevent disease?

## Economics

- **Economics** is the study of how people choose to use resources to produce goods and services, and how those goods and services are distributed to the public.
- Economists look at resources as the available supply of something that can be used.
- There are three categories of resources:
  - Labor (human resources)
  - Capital (technology and knowledge)
  - Land (natural resources)

## Resources

- **Natural resources** are structures and processes humans can use for their own purposes but cannot create.
  - **Renewable resources** can be formed or regenerated by natural processes.
  - **Nonrenewable resources** are not replaced by natural processes, or the rate of replacement is so slow as to be ineffective.

## Environmental Costs

- Pollution, species extinction, resource depletion, and loss of scenic quality are all examples of the **environmental costs** of resource exploitation.
- **Deferred costs** are those that may not be immediately recognized and must be paid at a later date.
  - Agricultural soil erosion
- **External costs** are those that are borne by someone other than the individuals using the resource.
  - Cleanup of hazardous waste sites

## Cost-Benefit Analysis

- **Cost-benefit analysis** is a formal quantitative method of assessing costs and benefits of competing uses of a resource, or solutions to a problem, and deciding which is most effective.

## Cost-Benefit Analysis

- It is used to determine whether a policy generates more social costs than social benefits and, if benefits outweigh costs, how much activity would obtain optimal results.
- There are four steps in a cost-benefit analysis:
  - Identification of the project.
  - Determination of all impacts.
  - Determination of the value of impacts.
  - Calculation of net benefit.
- Not everything can be analyzed from an economic point of view, or can be assigned an economic value.
- ***\*\*Let's go Fishin' Exercise\*\****

## Common Property Resource Problems—The Tragedy of the Commons

- ❖ Economists have stated that when everybody shares ownership of a resource, there is a strong tendency to overexploit and misuse that resource.
- ❖ The problems inherent in common ownership of resources were outlined by biologist Garrett Hardin in his essay “The Tragedy of the Commons” (1968).

## Common Property Resource Problems—The Tragedy of the Commons

- ❖ The “Commons” were pasturelands in England provided free by the king to anyone wishing to graze cattle.
- ❖ There are no problems on the commons as long as the number of animals is small in relation to the size of the pasture.
- ❖ However, the optimal individual strategy is to enlarge one’s personal herd as much as possible.

## Common Property Resource Problems—The Tragedy of the Commons

- As each herder pursues the optimal strategy:
  - Each herd increases in size.
  - Commons becomes overgrazed.
  - Everyone loses as the animals die of starvation.
  - **Even though the eventual result is clear, no one acts to avert disaster.**

## Using Economic Tools to Address Environmental Issues

- A **subsidy** is a gift from the government to individuals or private enterprise to encourage actions considered important to the public interest.
  - Subsidies are useful when they have a clear purpose and are used for short transition periods.
  - When used inappropriately, subsidies can lead to economic distortions.
    - Keeps price of a good or service below true market value.
    - May encourage activities detrimental to the environment.
  - Once subsidies become part of the economic fabric of a country, they are very difficult to eliminate.

## Life Cycle Analysis and Extended Product Responsibility

- **Life-cycle analysis** is the process of assessing environmental effects associated with production, reuse, and disposal of a product over its entire useful life.
  - This process can identify changes in product design and process technology that would reduce the ultimate environmental impact of the product.
  - The story of stuff: <http://www.storyofstuff.com/>

## Economics and Sustainable Development

- Sustainable development has become an important policy priority for the world.
- **Sustainable development** is development that meets present needs without compromising the ability of future generations to meet their own needs.
  - Most definitions refer to the viability of natural resources and ecosystems over time, and to maintenance of human living standards and economic growth.

## The Nature of Science

- **Science** is a process used to solve problems or develop an understanding of nature that involves testing possible answers.
- The **scientific method** is a way of gaining information (facts) about the world by forming possible solutions to questions, followed by rigorous testing to determine if the proposed solutions are valid.

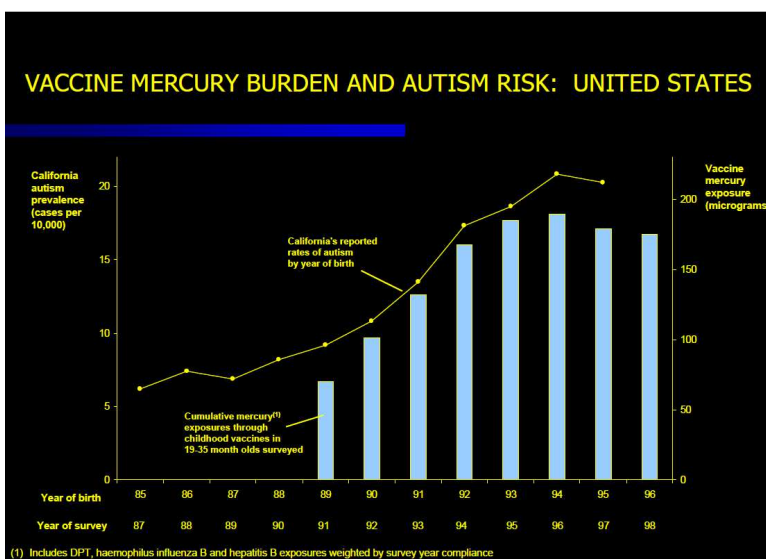
## Basic Assumptions in Science

- **Presumptions**
  - Specific causes exist for observed events.
  - These causes can be identified.
  - General rules or patterns can be used to describe observations.
  - Repeated events probably have the same cause.
  - Perceptions are not individualistic.
  - Fundamental rules of nature are universal.

## Elements of the Scientific Method

- ❖ Scientists distinguish between situations that are merely correlated (happen together) and those that are correlated and show cause-and-effect relationships.
- ❖ The scientific method requires a systematic search for information and continual evaluation to determine if previous ideas are still supported.
- ❖ Scientific ideas undergo constant reevaluation, criticism, and modification.

## Vaccines and Autism



## Vaccines cause autism (?)

- [http://www.google.com/imgres?imgurl=http://www.healingourchildren.net/Are\\_Vaccine\\_Safe/vaccine\\_prevalence\\_charts.gif&imgrefurl=http://www.healingourchildren.net/Vaccine/vaccines\\_cause\\_autism.htm&usg=\\_\\_VoEMKz6US46Y7JBEBdzCtZmWfwg=&h=337&w=506&sz=72&hl=en&start=70&sig2=zU4NoiGCmnU252Kt0qJw2w&itbs=1&tbnid=JVbvBS9\\_\\_4gbpM:&tbnh=87&tbnw=131&prev=/images%3Fq%3Dautism%2Bvaccines%26start%3D60%26hl%3Den%26sa%3DN%26gbv%3D2%26ndsp%3D20%26tbs%3Disch:1&ei=qLHoS8LTGIWglAfjq5zrCg](http://www.google.com/imgres?imgurl=http://www.healingourchildren.net/Are_Vaccine_Safe/vaccine_prevalence_charts.gif&imgrefurl=http://www.healingourchildren.net/Vaccine/vaccines_cause_autism.htm&usg=__VoEMKz6US46Y7JBEBdzCtZmWfwg=&h=337&w=506&sz=72&hl=en&start=70&sig2=zU4NoiGCmnU252Kt0qJw2w&itbs=1&tbnid=JVbvBS9__4gbpM:&tbnh=87&tbnw=131&prev=/images%3Fq%3Dautism%2Bvaccines%26start%3D60%26hl%3Den%26sa%3DN%26gbv%3D2%26ndsp%3D20%26tbs%3Disch:1&ei=qLHoS8LTGIWglAfjq5zrCg)

## So remove thimerosal

- <http://www.webmd.com/brain/autism/news/20080107/thimerosal-down-but-autism-rising>
- OK, maybe it's not thimerosal, its giving the MMR together as 1 dose:
  - <http://www.newscientist.com/article/dn7076>
- OK, it's not all those other things we said, but it is still the vaccines, so we are going to not vaccinate so we can have healthy children:
  - <http://briandeer.com/mmr-lancet.htm>
  - <http://www.npr.org/templates/story/story.php?storyId=125570056>

## Elements of the Scientific Method

- Observation occurs when we use our senses or extensions of our senses to record an event.
  - Scientists refer to observations as careful, thoughtful recognitions of events.
- Observations often lead to additional questions about the observations.
  - The way questions are asked will determine how one goes about answering them.
- Exploring other sources of knowledge is the next step to gain more information.

## Elements of the Scientific Method

- A **hypothesis** is a testable statement that provides a possible answer to a question, or an explanation for an observation.
  - A good hypothesis must be logical, account for all relevant information currently available, allow prediction of related future events, and be testable.
    - Given a choice, the simplest hypothesis with the fewest assumptions is the most desirable.

## Elements of the Scientific Method

- An **experiment** is a re-creation of an event that enables an investigator to support or disprove a hypothesis.
  - A **controlled experiment** divides the experiment into two groups (experimental and control) that differ by only one variable.
- **Reproducibility** is important to the scientific method. A good experiment must be able to be repeated by independent investigators to ensure a lack of bias.

## Elements of the Scientific Method

- When broad consensus exists about an area of science, it is known as a theory.
  - A **theory** is a widely accepted, plausible generalization about fundamental scientific concepts that explains why things happen
    - e.g., physicists have a theory of gravity explaining why objects with mass are attracted to each other
- Scientists often discuss **paradigms**, the set of ideas and practices that define a scientific discipline at a given time
  - These can be stable for quite some time, and when (if?) they change it is referred to as a **paradigm shift** (geocentric, heliocentric universe)
- A **scientific law** is a uniform or constant fact of nature that describes what happens in nature
  - (e.g., um, gravity again! But this time referring to the fact that things always fall to the Earth and not 'why' they fall)



## Pseudoscience

- **Pseudoscience** is a deceptive practice that uses the appearance or language of science to convince, confuse, or mislead people into thinking that something has scientific validity when it does not.
- Often fail to have many (or any) characteristics of science such as reproducibility or the ability to be falsified
- Includes subjects such as cryptozoology, homeopathy, astrology, and chiropractic, to name a few.